Low Profile Fan Duct Design Guidelines

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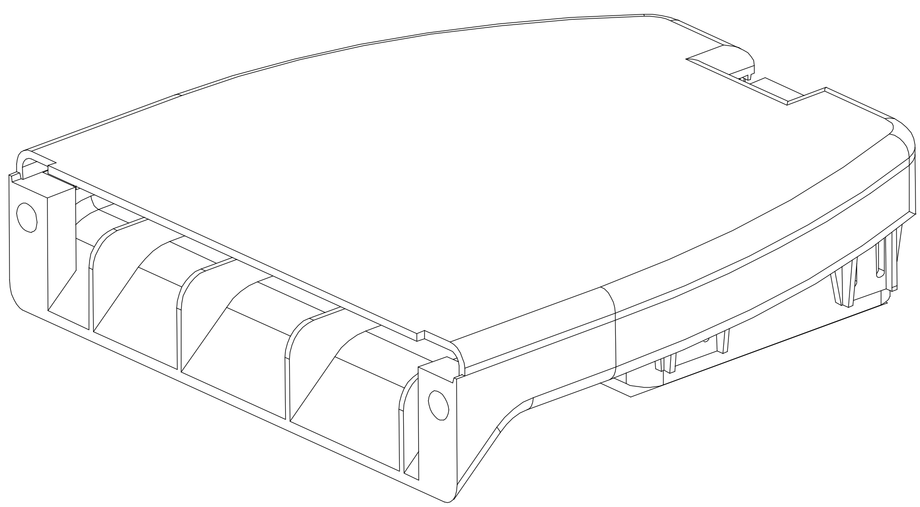

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1 Introduction

The following document provides information on designing, manufacturing, and assembling a Low Profile Fan Duct system per the ***Low Profile Fan Duct Motherboard and Chassis and Ingredients Specifications***. Although this guideline will use a single reference design as an example, the Fan Duct and system designer should adapt this design to meet their specific system design needs.

2 Ducting Philosophy

As the thermal demands of today's computer systems increases, it becomes necessary to manage both the internal chassis temperature and the airflow to the Core Logic components (processor, chipset, graphics, graphics controller, and memory). In order to meet the increased thermal demands, additional heat sinks or increased air velocities are required for cooling the Core Logic components. The recommended low-cost alternative to this is to use the Low Profile Fan Duct in ATX or micro-ATX systems. The Low Profile Fan Duct impinges high velocity air from outside the chassis directly to the Core Logic components.

3 Chassis Recommendations

3.1 Venting

The Low Profile Fan Duct system requires an inlet vent in the ATX or micro-ATX chassis. The internal fan within Fan Duct, pulls cool exterior air through the vent into the duct. Air from the internal fan then impinges on the Core Logic components. In order to balance airflow and EMI containment, the size of the vent hole openings and the spacing between holes is limited. One metric for gauging venting of perforated metal is by the percent open. This is defined by the open area (the open area is the summation of the hole areas) divided by the total area (area of holes plus solid metal between holes). This is an averaged value. For the Low Profile Fan Duct to be able to deliver full performance, the vent area must be a minimum of 50% to a maximum of 60% open. For EMI containment and to prevent dust clogging of the vent, hole dimensions must be in the range of 0.12 inches to 0.17 inches (3.0 mm to 4.3 mm). See **Section 4.1.1** for additional details.

3.1.1 Vent Fabrication

The venting can be fabricated in a number of ways. The two primary methods are to:

1) Punch the vent holes in the back panel as shown in **Figure 1** or,
2) Incorporate a perforated sheet metal hole pattern with an EMI gasket to maintain chassis shielding effectiveness, see **Figure 2**.

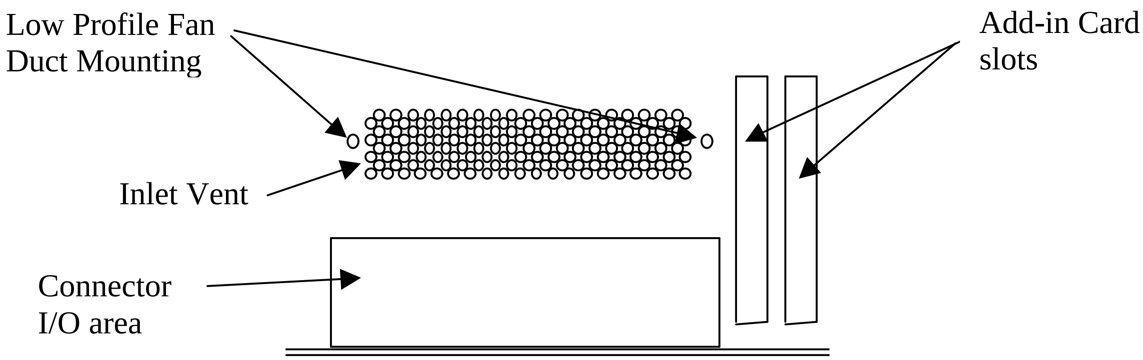


Figure 1. Typical ATX I/O Back Panel with a 60% Open Hole Pattern

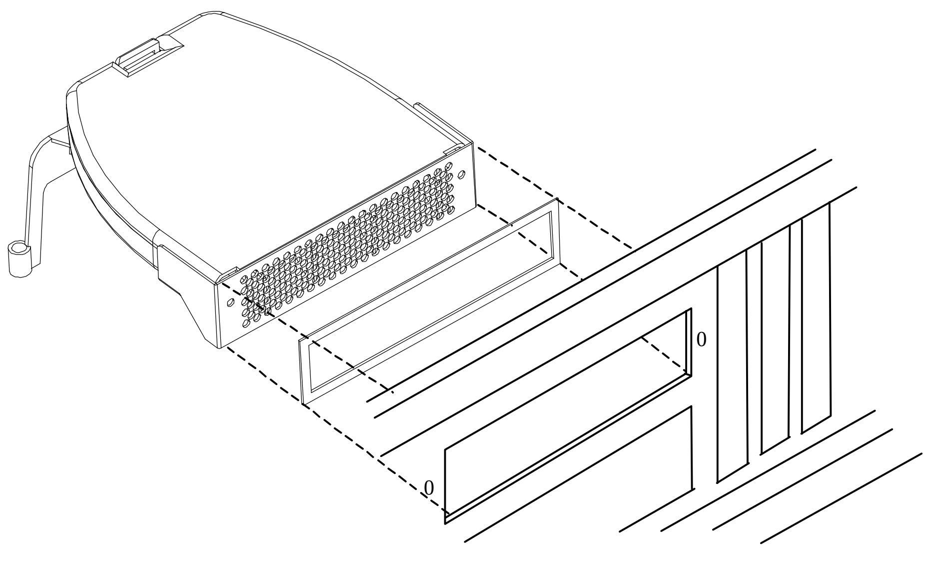


Figure 2. Exploded View of an EMI Gasket and Pre-Stamped Bracket
(hole pattern is the same as shown in Figure 1)

When using a pre-fabricated hole pattern, it is extremely important to have proper grounding around the perimeter of the chassis opening between the perforated mounting bracket and the chassis opening. The ground point spacing should be no greater than 0.17 inches (4.3 mm). These grounding solutions can be achieved using a compliant electrically conductive material or a stamped metal bracket, which has spring fingers at a spacing of 0.17 inches or less.

3.2 Keep Out Areas

There are keep out zones required in fitting a Low Profile Fan Duct in an ATX or micro-ATX chassis. The Low Profile Fan Duct style was intended to fit chassis with power supplies that sit above or off to the side of the motherboard. The specific keep outs for the chassis include the power supply, drive bays, and cabling.

3.2.1 Power Supply

The majority of chassis with standard power supplies will accommodate a Low Profile Fan Duct system. The following is a list of the guidelines for power supplies:

1) When using an ATX or micro-ATX chassis, the power supply should have the fan mounted internally. The recommended airflow direction is to exhaust air from the power supply out the rear of the chassis. The inlet vent on the power supply should be on the front or side of power supply, not on the side that would be blocked by the Fan Duct.
2) The recommended position of the power supply is to mount it off to the side of the motherboard.

3.2.2 Drive Bays

The drive bays should be mounted as far away from the motherboard as possible to simplify cabling. At a minimum, the drive bays and peripherals should not interfere with the ATX or micro-ATX motherboard keep out specifications.

3.2.3 Cabling

For optimal cabling placement, the IDE and power connectors should be located in the shaded areas shown in **Figure 3**. In addition, the drives should be located as far from the motherboard as possible in order to allow easy connection of cables. Additional assembly considerations are discussed in Section 5.

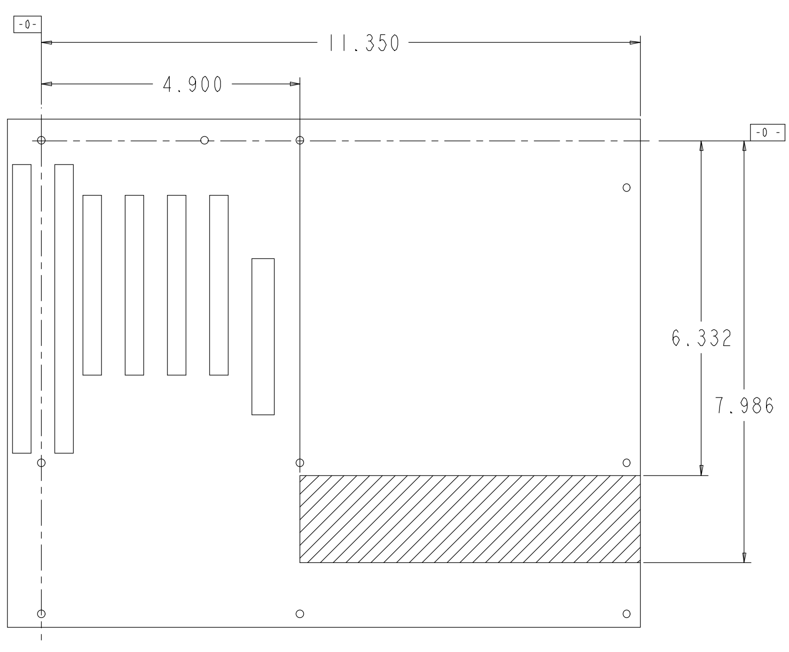


Figure **3.** Optimal Placement for the IDE and Power Connectors

4 Duct Design Recommendations

Thermal and structural test validation methodology can be found in the Appendix. The following sections provide a summary of the recommendations for complying with the Low Profile Fan Duct specifications.

4.1 Thermal Design

The primary purpose of the Low Profile Fan Duct is to cool the Processor and Core Logic components most efficiently and at the lowest cost. The two primary thermal advantages of Fan Duct are that it provides high velocity air at the lowest possible air temperature directly to the Core Logic components. The close proximity of the Fan Duct's fan to the Core Logic components allows the fan to impinge directly on the processor's heat sink as well as the other Core Logic components. The following sections provide specific information on optimizing the performance of the Low Profile Fan Duct.

4.1.1 Thermal Requirements

The Low Profile Fan Duct must cool the Processor and Core Logic components to their required Junction or Case Temperatures. There are four primary conditions that the Fan Duct reference design must meet (see Appendix for thermal test and loading details):

1) Provide sufficient cooling to not require heat sinks on any of the Core Logic components, except for the processor.
2) Not negatively impact the cooling of the remainder of the chassis (hard drives, add-in cards, or power supply).
3) Thermal validation testing must utilize maximum power dissipating software for each of the Core Logic components.
4) The ATX or micro-ATX system for the validation testing must be heavily loaded.
5) Test under worst case environmental conditions, typically 35°C outside of chassis.

It should be noted that when thermal testing with fixed speed fans, the testing can be performed at ambient temperatures lower than 35°C, then extrapolated to 35°C. As example, a test is performed using a fixed speed fan (no fan speed control). The test is performed in a 26°C ambient environment. The results can be scaled to 35°C by adding the difference of 9°C (35°C - 26°C = 9°C) to the results measured at 26°C.

4.1.2 Volume Airflow

It was determined that to meet the four conditions outlined in Section 4.1.1 requires a minimum of 20 Cubic Feet per Minute (CFM) volumetric airflow from the Fan Duct. If the system configuration is not as severe as those listed, the volume airflow and related fan speed can be reduced, but would need to be revalidated. The Low Profile Fan Duct specifications require that the basic geometry of the inlet vent and duct not prevent the Fan Duct from being able to provide 20 CFM of airflow to the Core Logic components, when using typical 80 mm axial fans in the Fan Duct. This does not mean that lower speed fans or fans that use fan speed control can not be used in Fan Duct. Another design option is to integrate the fan directly in the Fan Duct.

The volume airflow is measured at the inlet vent into the ATX or micro-ATX chassis. The power supply is operating per the conditions outlined in Section 4.1.1. One method of estimating the volume airflow is by attaching a collar around the intake vent and measuring the average air velocity into the collar area. The collar area is measured and converted to square feet. This area is multiplied by the average air velocity into the collar resulting in a measurement of volume airflow (Cubic Feet per Minute or CFM). The collar should be 2.0 to 4.0 inches tall and not block the airflow into the vent. Air velocities are typically measured with hot-wire anemometers.

If the Fan Duct has speed control circuitry to reduce the speed of the fan when operated in less than 35°C environments, the volume airflow requirement can be reduced while operating at the lower temperature. The primary reason for using fan speed control is to reduce the acoustic noise produced by the Fan Duct. An example of this is to run the fan in the Fan Duct at a lower speed when the inlet air temperature to the Fan Duct is at 25°C. A typical approach would be to reduce the voltage to the fan from 12 volts (nominal) to 7 volts. If the inlet air temperature should rise to a higher specified value of 35°C, the speed of the fan is increased to 12 volts (nominal). Equation 1 can be used to estimate the change in sound pressure level at different fan speeds.

Equation 1:
SPL (change measured in dB) = $50*LOG(RPM_1/RPM_2)$
where,
SPL = decrease/increase in sound pressure level, dB
RPM_1 = rotational speed 1 of fan, RPM
RPM_2 = rotational speed 2 of fan, RPM

As an example, if the voltage to the fan is reduced from a nominal value of 12 volts to 7 volts, the rotational speed of the fan is reduced to a factor of 0.58, resulting in a decrease of 12 dB from the original sound pressure level. **Caution should be exercised in determining the starting voltage or low speed voltage setting for the fan. Typically the minimum starting voltage for a 12 volt**

(nominal) axial DC fan is 6 to 7 volts. This value needs to be worked out with the fan supplier. For more information on fan speed control, see the ***Low Profile Fan Duct Ingredients Specification, Section 4.1***.

4.1.3 Airflow Through Fan Duct

Airflow restrictions should be minimized within the Low Profile Fan Duct for maximum performance. The three basic guidelines for designing the interior of the Low Profile Fan Duct are:

(1) Use an inlet vent pattern that is least restrictive to airflow, but that does not cause EMI problems
(2) Use smooth gradual transitions to minimize flow impedance's
(3) Internal structural ribbing should follow the contours of the airflow

4.1.4 Inlet Vent Design

The air inlet vent geometry for the Low Profile Fan Duct has the largest affect on the volumetric airflow through the Low Profile Fan Duct. In order to balance airflow and EMI containment, the size of the vent hole openings and the spacing between holes is limited. One metric for gauging venting of perforated metal is by the percent open. This is defined by the open area (the open area is the summation of the hole openings in a given area) divided by the total area (area of holes plus solid metal between holes). This is an averaged value. For the Low Profile Fan Duct to be able to deliver full performance, the vent area must be a minimum of 50% to a maximum of 60% open. For EMI containment and to prevent dust from clogging the inlet vent, hole dimensions must be in the range of 0.12 inches to 0.17 inches (3.0 mm to 4.3 mm). See **Section 3.1** for additional details.

A metric for understanding the effect of the vent geometry on the flow of air through the vent is the static pressure drop of the air as it moves through the vent. This is one of several pressure drops that the fan in the Fan Duct must overcome. This pressure drop can be thought of as a drag loss and is typically measured in inches of water. For a vent that uses perforated sheet metal, a method of comparing pressure drops is shown in **Equation 2** and **Table 1**,

Equation 2:

$$P_{DROP} \propto HL / (A_{TOTAL})^2$$

where,
P_{DROP} = Static pressure drop, inches of water
HL = Head Loss Coefficient, see Table 1
A_{TOTAL} = Total unblocked vent area, in^2

Table 1

% Open	HL
40	8.0
50	3.5
60	2.0
70	1.2

Equation 2 is to be used for comparative purposes only. Additional coefficients must be included to determine the actual pressure drop. As the percent open for a given perforated vent area increases, the associated HL drops dramatically, especially going from 40% open to 50% open, see **Table 1**. An even larger factor is A_{TOTAL}, which is the vent area that the air must flow through, since this term is squared and then divided into the HL term. The percent open of the perforated sheet metal is limited by EMI containment requirements, and the ability to manufacture the perf pattern. Vent areas using greater than 60% open perforated sheet metal are more difficult and thus more expensive to produce and may result in EMI problems. Another example of a pre-fabricated vent pattern is shown in **Figure 4**.

The Low Profile Fan Duct airflow requirements can be met by using a staggered hole pattern as shown in **Figure 5**. The percent open for a staggered hole pattern can be calculated using **Equation 3,** where D_h is the diameter of the hole. A hexagonal pattern is shown in **Figure 6**. The equation for calculating the percent open using a hexagonal hole pattern is shown in **Equation 4**, where D_h must be equal to or less than 0.170 inches (4.3 mm). A staggered square pattern is shown in **Figure 7**. The associated percent open can be calculated using **Equation 5**, where D_h is now the diagonal of the square and again must be less than 0.170 inches (4.3 mm) for EMI containment.

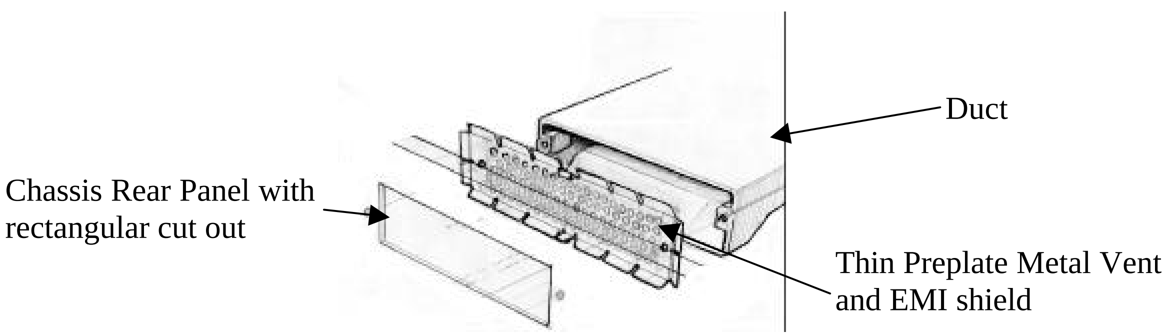


Figure 4. Example of a Pre-Fabricated Vent Pattern.

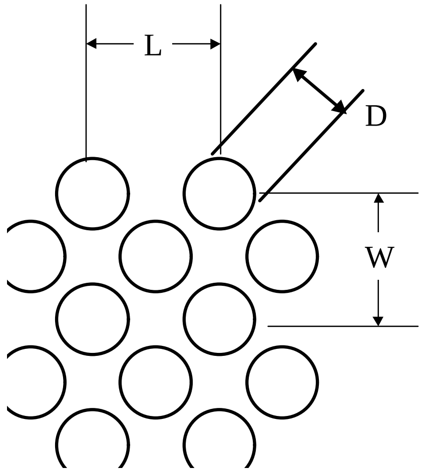
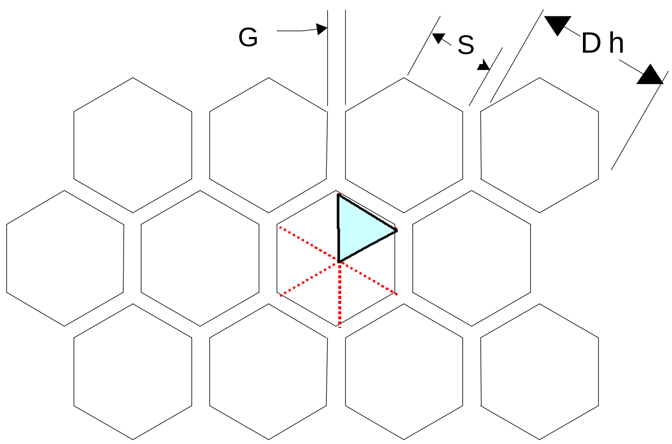


Figure 5. Vent Dimensions for Staggered Circular Hole Pattern

Equation 3:

Percent Open for Staggered Circular Hole Pattern = π*D^2*100 / (2*L*W)



D_h = 2*S

Figure 6. Vent Dimensions for Staggered Hexagonal Hole Pattern

Equation 4:

Percent Open for Hexagonal = (519.6*S^2) / (5.196*S^2 + 6*S*G + 1.732*G^2)

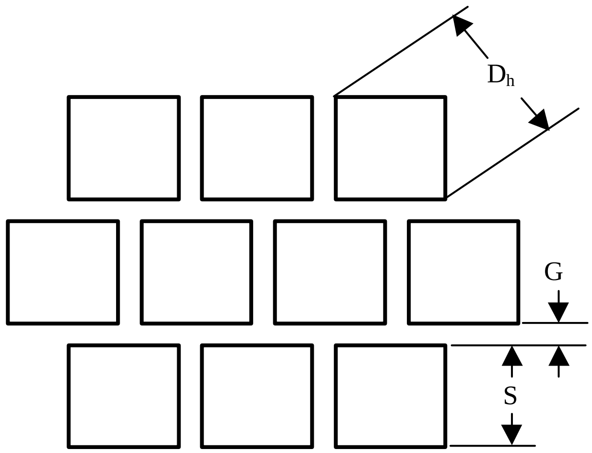


Figure 7. Vent Dimensions for Staggered Square Hole Pattern

Equation 5:
Percent Open for Staggered Square Hole Pattern $= 100*S^2 / (S + G)^2$

4.1.5 Fan Duct Shape

The Low Profile Fan Duct shape is important in minimizing the static back-pressure that the fan must overcome. In general, the Fan Duct should provide smooth airflow transitions whenever there are varying cross-sections. Examples of these smooth transitions are shown in **Figure 8**.

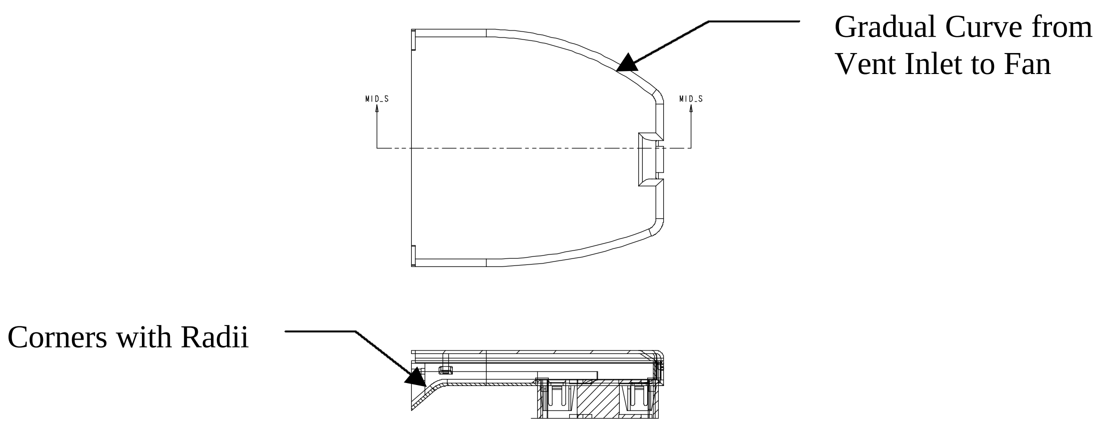


Figure 8. Two Examples of Gradual Cross Section Transitions

4.1.6 Duct Ribbing

When using ribbing to strengthen the Fan Duct, the ribbing should always follow the airflow contours to the fan, as shown in **Figure 9**.

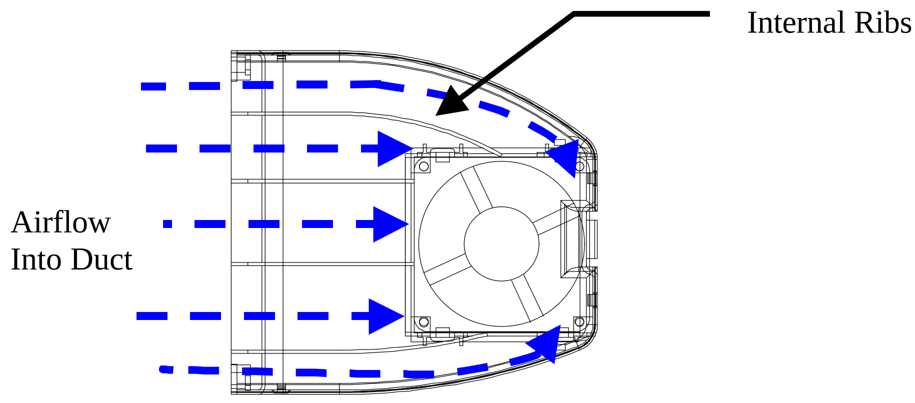


Figure 9. Structural Ribbing Follows the Airflow Contours

4.1.7 Air Temperature

The Low Profile Fan Duct utilizes cool external air to provide the lowest possible air temperature to the Processor and Core Logic components. The typical air temperature within ATX or micro-ATX systems is 10°C to 20°C higher than the air temperature outside the chassis. The Low Profile Fan Duct provides a 10°C to 15°C advantage over the typical ATX system.

When the power supply is positioned to the left of the Fan Duct (as viewed from the rear of the chassis), there is a potential 1°C to 3°C air temperature rise to the Core Logic components. This results from the recirculation of exhaust air from the power supply, which is mixed with cool exterior air outside of the chassis before being pulled into the Fan Duct. It was determined that recirculation in this configuration is not a problem unless the chassis is less than or equal to 3.0 inches from a wall. This is not likely to happen as a result of cabling from the rear of the chassis.

Another power supply placement scenario is above the Low Profile Fan Duct, see **Figure 10**. In this case it is more likely that recirculation will be a problem. A solution to prevent this type of recirculation is the use of an external duct as shown in **Figure 11**.

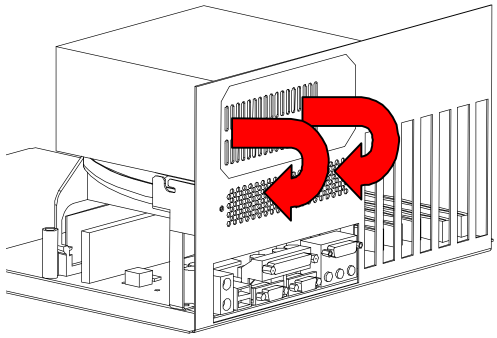


Figure 10. Exhaust air Recirculation from Power Supply to the Low Profile Fan Duct

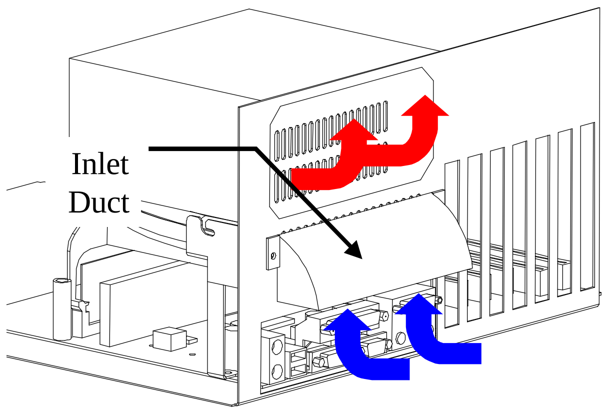


Figure 11. Inlet Duct Mounted to the Fan Duct Intake Vent

4.2 Structural Design

In order to prevent damage to system components, the Low Profile Fan Duct must withstand environmental shipping and handling requirements. The shipping requirements vary for the different system integrators. The following recommendations are based on tests using the Intel environmental shipping requirements found in Appendix B. The Low Profile Fan D reference design meets the Intel shock and vibration requirements as shown in the slow motion video still in **Figure 12**.

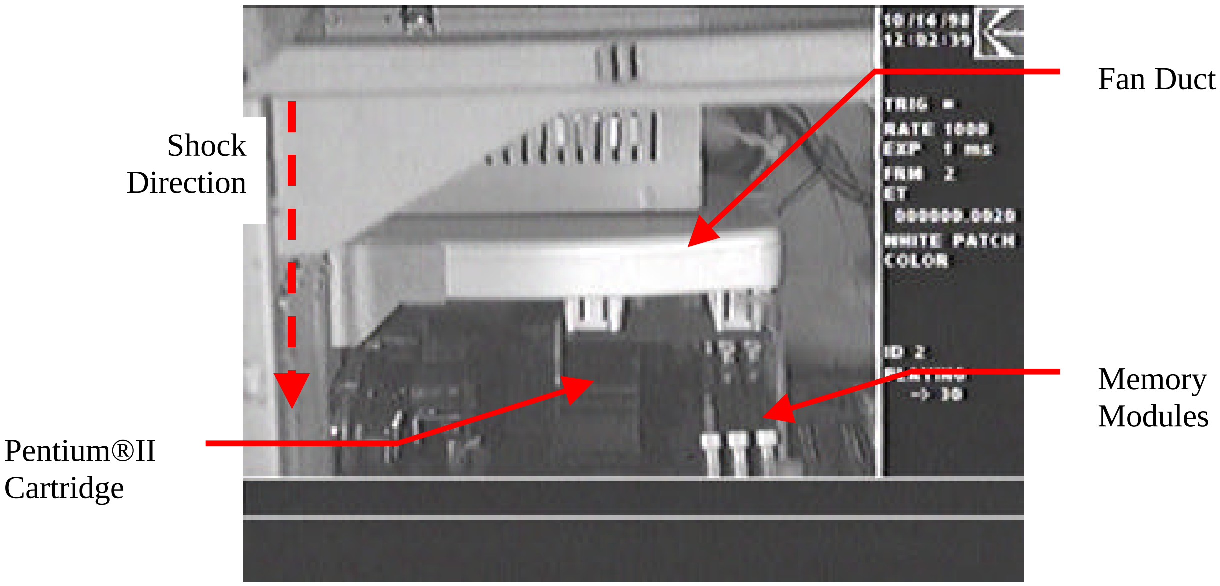


Figure 12. Negligible Fan Duct Deflection Using Motherboard and I/O Bracket
(30-G trapezoidal Drop Test)

4.2.1 Fan Duct Mounting

In both computer simulations and experiments, the Low Profile Fan Duct required support from the back panel and a rear support bracket as shown in **Figure 13**. The motherboard support bracket helps prevent excessive back panel flexure. **Although the reference design used a rear support bracket and motherboard bracket, the motherboard bracket may not be required in all chassis.** Testing should be used to determine if the bracket is necessary or not. Please note that the computer model of the duct was simplified to allow for faster simulation times. Shock tests done without rear bracket supports can cause the back panel to permanently deform or the Low Profile Fan Duct to hit the system components.

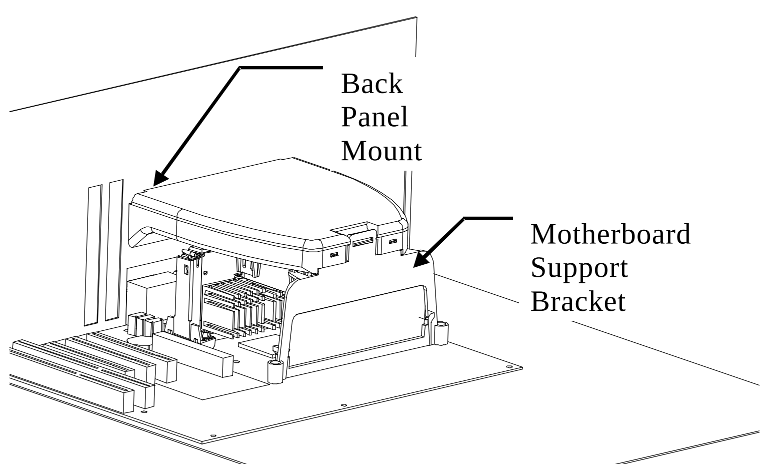


Figure 13. Fully Supported Low Profile Fan

In addition to holding the Low Profile Fan Duct in place, the Fan Duct should be easily removable in order to replace system components. The access to the processor core components can be done using a snap rear bracket design and two screws in the back panel. The assembly procedure of the Fan Duct is shown in Section 5.

4.2.2 Fan Mounting

There are a number of ways to mount the fan in the duct. In order to simplify the duct assembly, the recommended approach for mounting the fan is using snaps molded into the duct. The snap used in the reference design provides a locking engagement on the fan when a downward force is applied as shown in **Figure 14**. There are four molded pins that interact with the fan mounting holes to prevent movement in the other axes, see **Figure 14.**

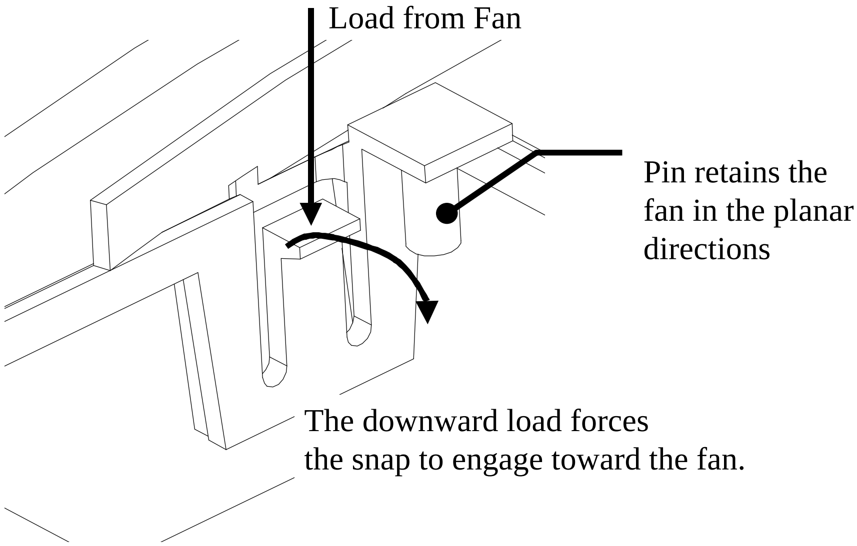


Figure 14. Snap Lock Feature in Reference Design for Fan Retention

4.2.3 Fan Location

The fan is offset toward the add-in cards and AGP card to improve airflow to those components and to provide hard drive and cable clearances. This is beneficial for compact systems such as micro-ATX, see **Figure 15**.

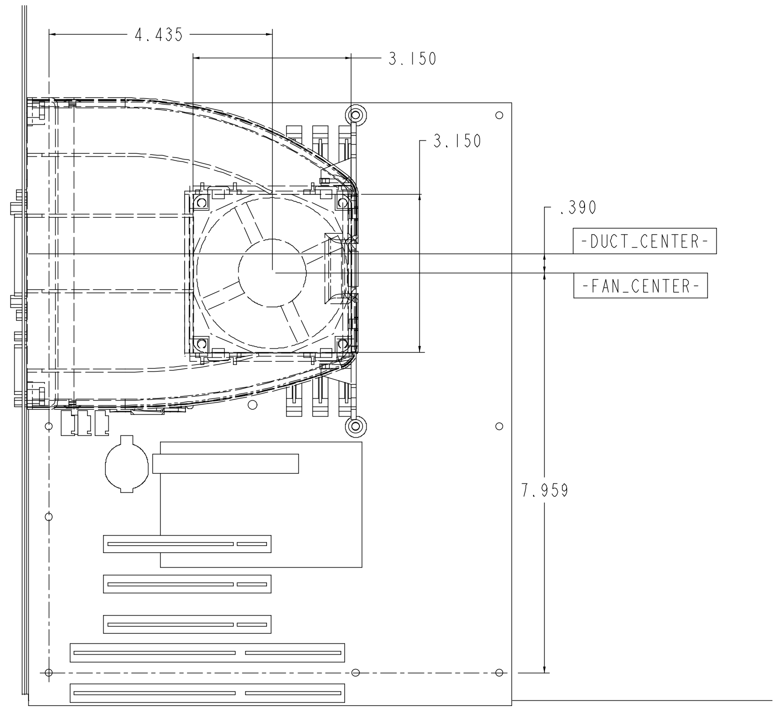


Figure 15. Fan Location in Reference Design

4.2.4 Ribbing

The Low Profile Fan Duct reference design uses ribbing to prevent the Fan Duct from flexing. The structural ribs can be 0.3 inches tall if they run parallel to the airflow. In order to minimize airflow resistance, the Fan Duct should contain no more than four ribs.

4.3 EMI Design

4.3.1 Fan Cabling

In order to minimize Electro-Magnetic Interference (EMI) radiation, the fan cable should be plugged into the power supply harness. Plugging the Fan Duct fan directly into the motherboard can result in a 6 dB increase in EMI.

4.3.2 Vent Hole Diameter and Shielding Properties

The air intake vent for the Low Profile Fan Duct requires hole openings in the range of 0.12 inches to 0.17 inches (3.0 mm to 4.3 mm). The maximum dimension for hole openings is defined as the greatest distance from any two vertices in a given hole. No additional EMI containment work is required when using a stamped vent pattern in the back panel of the chassis. In the case of using a prefabricated screen or hole pattern that fits to the chassis, steps must be taken to maintain the chassis shielding effectiveness. This can be achieved in one of two ways. Electrical contact between the air intake vent and the chassis must be maintained either:

(1) Continuously with the use of a gasket or similar conductive compliant material or,
(2) At discrete contact points not to exceed 0.17 inches (4.3 mm) apart. One way of achieving this is by the use of dimples.

4.3.3 Material

EMI radiation can be increased when using metal in the design of the Low Profile Fan Duct. Metal is a good structural material, but can cause EMI related problems and is not recommended. An example of this was the use of a metal plate in the bottom of the duct. Radiation levels increased when using a metal plate as the bottom of the Fan Duct (See **Figure 16**, as a bad design example). Additional testing revealed that metal mounting brackets and wire supports showed little increase in EMI radiation. The best design configuration for minimal EMI radiation is to design with non-conductive material such as plastic.

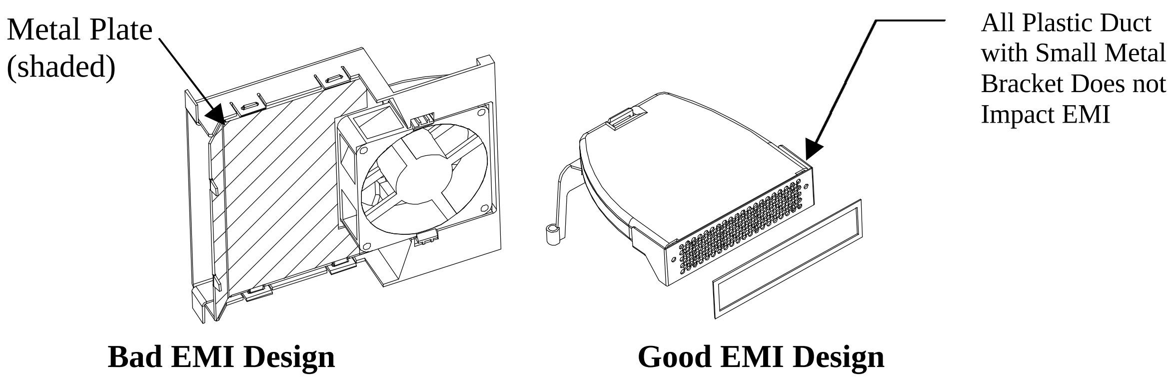


Figure 16. Good and Bad EMI Design Examples

4.4 Other Design Considerations

4.4.1 Designing for Variable Back Panel Lengths

Since the mounting scheme for the Low Profile Fan Duct uses the back panel, the Fan Duct and system designer must accommodate the variable back panel lengths. The plane of the back panel is either located in line with the I/O panel or in line with the ends of the add-in card brackets as shown in **Figure 17**. In order to accommodate the varying back panel locations, a bracket can be used as shown in **Figure 18**.

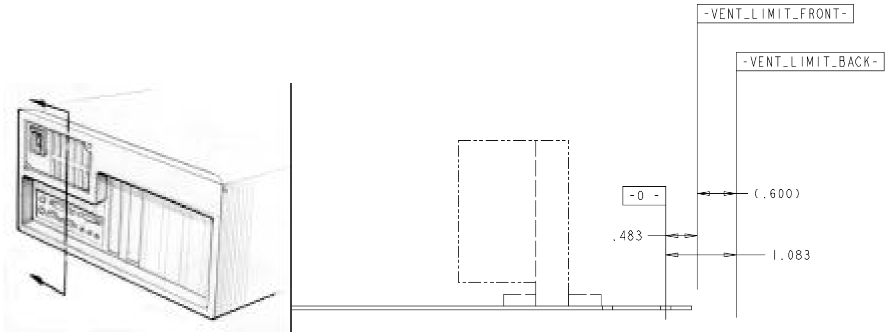
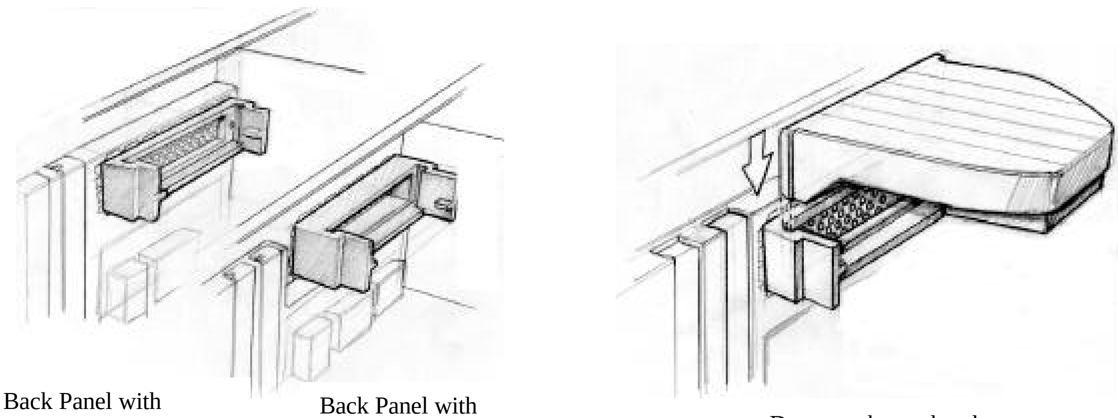


Figure 17. Back Panel Location with respect to the "0" Datum in the ATX Specification



Back Panel with Minimum length

Back Panel with Maximum length

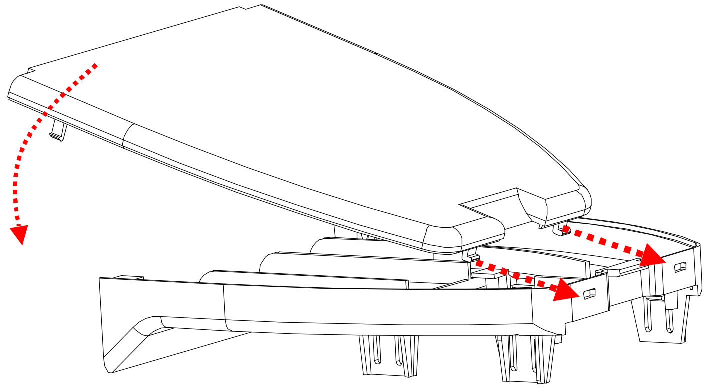
Duct attaches to bracket

Figure 18. Mounting Bracket Design Variations to Accommodate Back Panel Locations

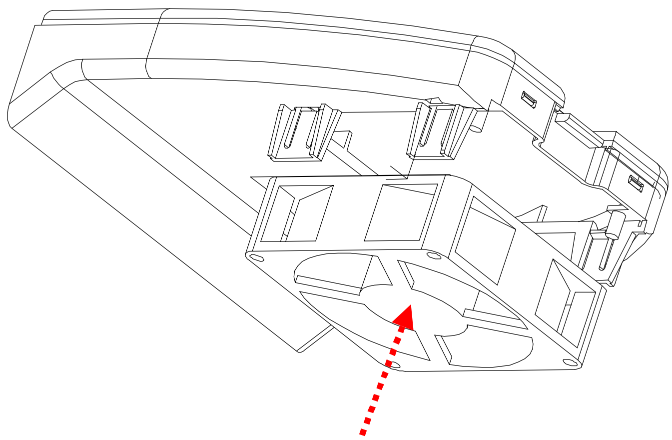
5 Assembly Recommendations

5.1 Duct Component Assembly

The duct component assembly will vary depending on design. The following example is based on the Low Profile Fan Duct reference design. In order to reduce tooling complexity and cost, the Fan Duct reference design has four components: the bottom duct, top cover, fan, and threaded inserts. The top duct, bottom duct, and fan are assembled using snaps since they can be designed into the plastic tooling easily. The threaded inserts (or captive nuts), used to assemble the duct into the chassis, should be pre-assembled in the bottom duct. The primary components can be assembled in two basic steps as shown in **Figure 19**.



Step 1



Step 2

Figure 19. Fan Duct Component Assembly.

5.2 Installation of Low Profile Fan Duct

The assembly of the Fan Duct to the chassis requires (1) screwing the rear bracket to the motherboard and (2) inserting and screwing the Fan Duct into the back panel. The Fan Duct reference design uses a rear bracket that is assembled to the middle two ATX stand-offs. The rear bracket should be assembled directly after the motherboard is assembled since it prevents cables from running between the fan on the duct and the processor core logic components. Once the cabling has been assembled, the Fan Duct should be inserted. The Fan Duct will either have studs or nuts pre-assembled to the Fan Duct body. After the studs are placed in through the holes as shown in **Figure 21**, the Fan Duct can be snapped into the rear bracket.

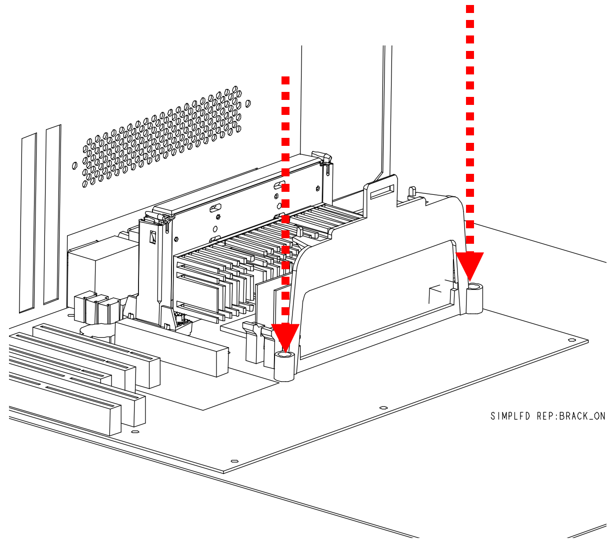


Figure 20. Assembly of the Rear Support Bracket to the Motherboard

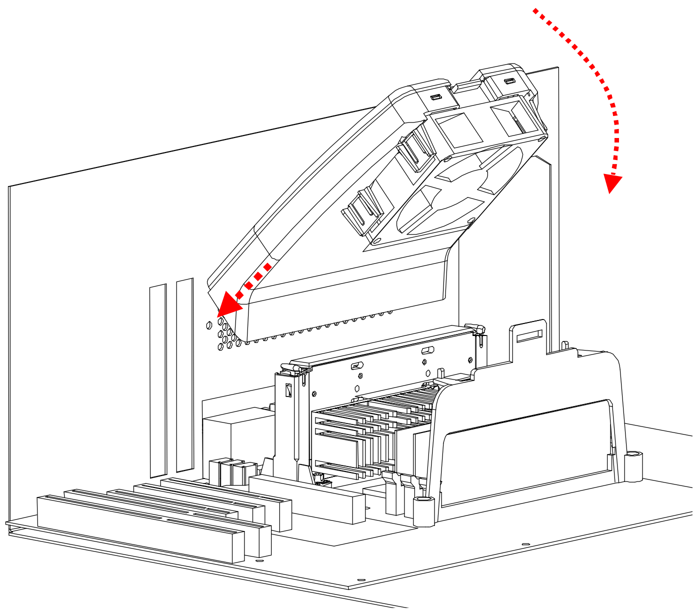


Figure 21. Fan Duct Insertion into the Chassis Assembly.

6 Heat Sink Design and Recommendations

6.1 Low Profile Heat Sink

In order to comply with the Low Profile Fan Duct specifications, a low profile heat sink is required. The low profile heat sink offers lower cost and weight advantages over the traditional heat sink. Drawings for the new heat sink can be found in Appendix C.

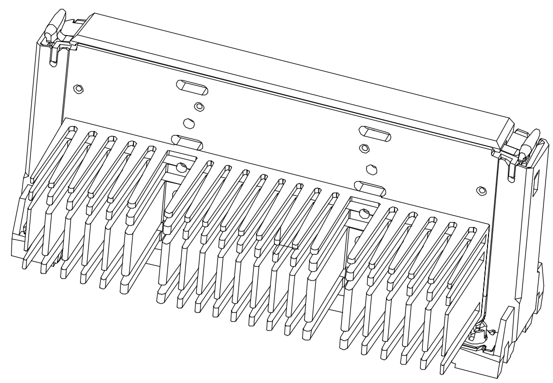


Figure 22. Low profile Heat Sink Assembled to the Pentium® II cartridge.

6.2 Heat Sink Attach Mechanism

6.2.1 SECC

The low profile heat sink utilizes the same attach mechanisms as the standard heat sink and thermal plate. The clip and riv-screw holes used by the low profile heat sink are currently in the thermal plate, as shown in **Figure 23**.

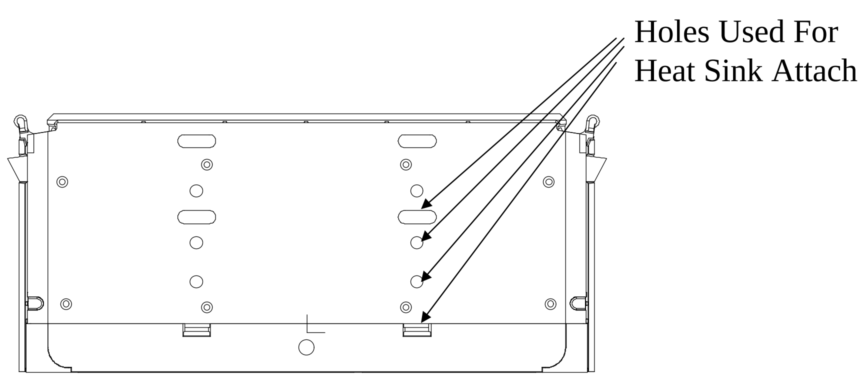


Figure 23. Pentium ® II Thermal Plate Mounting Holes

6.2.2 SECC2

When using the SECC2 processor form factor, the heat sink attach mechanism must also fit within the motherboard keep out areas found in the Low Profile Fan Duct Motherboard and Chassis Specification. The current reference design for the SECC2 heat sink will interfere with the Fan Duct. Alternative solutions to the SECC2 heat sink attach system will be published in a separate document. The application note and related information can be found at the following web site: http://developer.intel.com/ial/sdt/fanduct.htm.

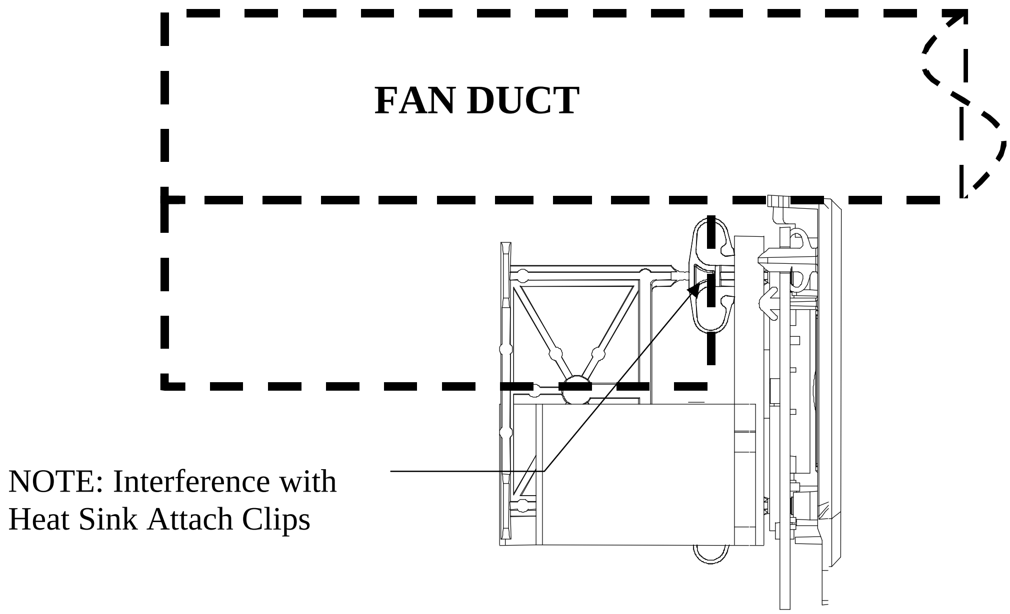


Figure 24. Interference of current Heat Sink Attach Clips with the Fan Duct

Appendix A: Thermal Test Setup

Introduction

This document provides the ATX or micro-ATX system configuration, temperature and airflow sensor locations to test the Low Profile Fan Duct system. The configuration is intended to represent a standard ATX desktop system. Although the following thermocouple and airflow sensors are the minimum required to validate the Low Profile Fan Duct system, additional sensors can be added provided they do not impede airflow within the system.

System Configuration

The following are the necessary components and component placement for testing the Low Profile Fan Duct system:

Component	Type	No.
Processor	300 MHz Klamath	1
Memory	100 Mhz, 128 Mb	3
Graphics	i740 2X AGP Graphics Card	1
Audio Modem Riser	Full Length (slot 7)	1
Processor Heat Sink	Low Profile ATXV1	1
PCI	10 Watt Load Card	4
ISA	10 Watt Load Card	1
Floppy Drive	Standard	1
Primary Hard Drive	2.1 GHz HDD	1
Secondary Hard Drives	SCSI HDD 7200 RPM (6 watt standby)	2
5.25” Drive	CD ROM	2
Power Supply	PS2	1
Motherboard	Seattle Fab D (ATX) Maui (micro-ATX)	1
Chassis	Midtower ATX or micro-ATX	1

Software Configuration

Appropriate power virus for: CPU, Memory, Chipset, and Graphics.
These tests are not to be run concurrently.

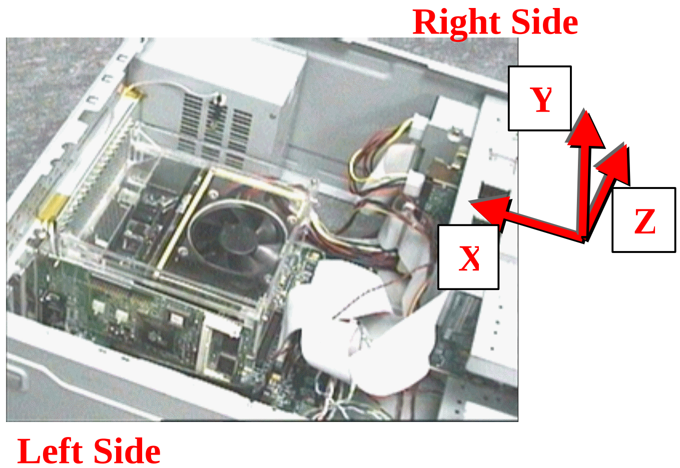
Thermocouple and Air Sensor Locations

There are several thermocouple and airflow sensors that are required to validate the system. The left and right directions are oriented based on the back panel facing north.

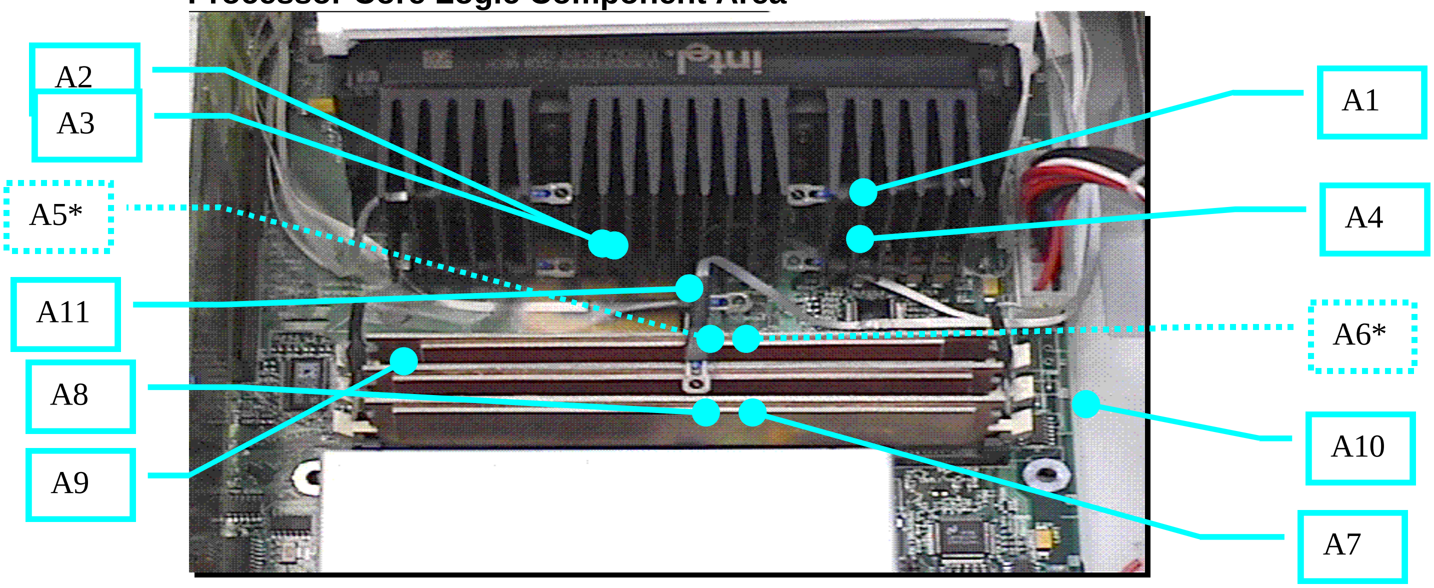
Airflow Sensor Locations

Sensor	Location	Flow Velocity Direction	No.
Processor	Top of heat sink, right side	Y	A1
Processor	Top of heat sink, left side	Y	A2
Processor	Bottom of heat sink, left side	Z	A3
Processor	Bottom of heat sink, right side	Z	A4
Memory	In front of first memory slot, parallel to memory, in center of memory card	Z	A5
Memory	In front of first memory slot, in center of memory card	Y	A6
Memory	In back of last memory slot, in center of memory card	Z	A7
Memory	In back of first memory slot, in center of memory card	Y	A8
Memory	On left side of memory slots as close to motherboard as possible	Z	A9
Memory	On right side of memory slots as close to motherboard as possible	Z	A10
Chipset	0.2” Above Chipset,	Y	A11
FDR Inlet	Behind FDR inlet vent, left side of vent	X	A12
FDR Inlet	Behind FDR inlet vent, center of vent	X	A13
FDR Inlet	Behind FDR inlet vent, parallel to motherboard, right side of vent	X	A14
Power Supply	In front of inside power supply vent	Z	A15
Power Supply	In front of outside power supply vent	X	A16
AGP	Below AGP processor chip	Z	A17
AGP	AGP airflow on the backside of card	Y	A18

Direction Orientation for Test Setup:



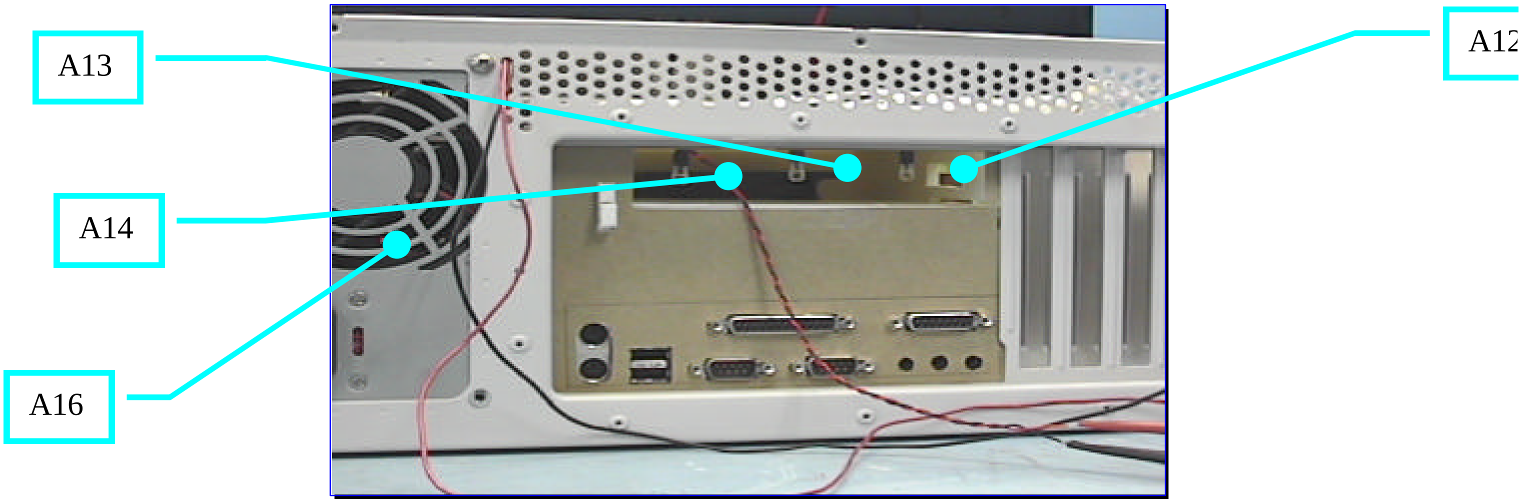
Processor Core Logic Component Area



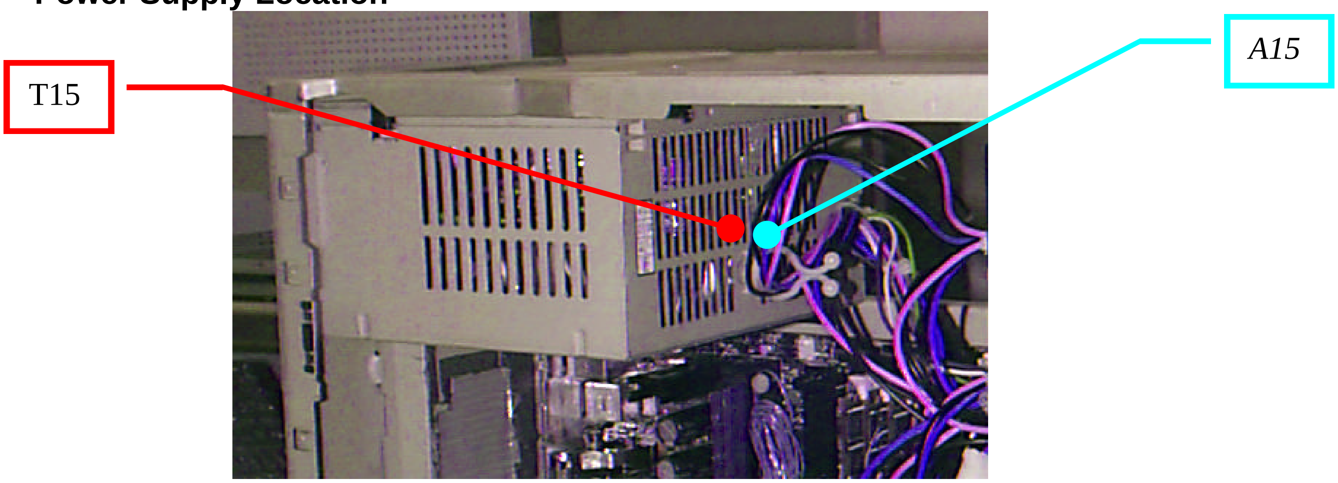
* The dashed lines indicate that probes are hidden behind the object

Fan Duct Vent

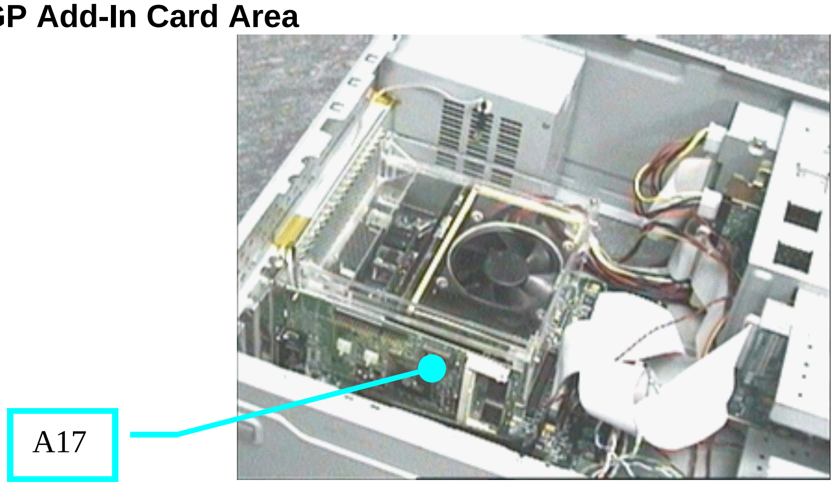
(Fan Duct perf pattern not shown for clarity)



Power Supply Location



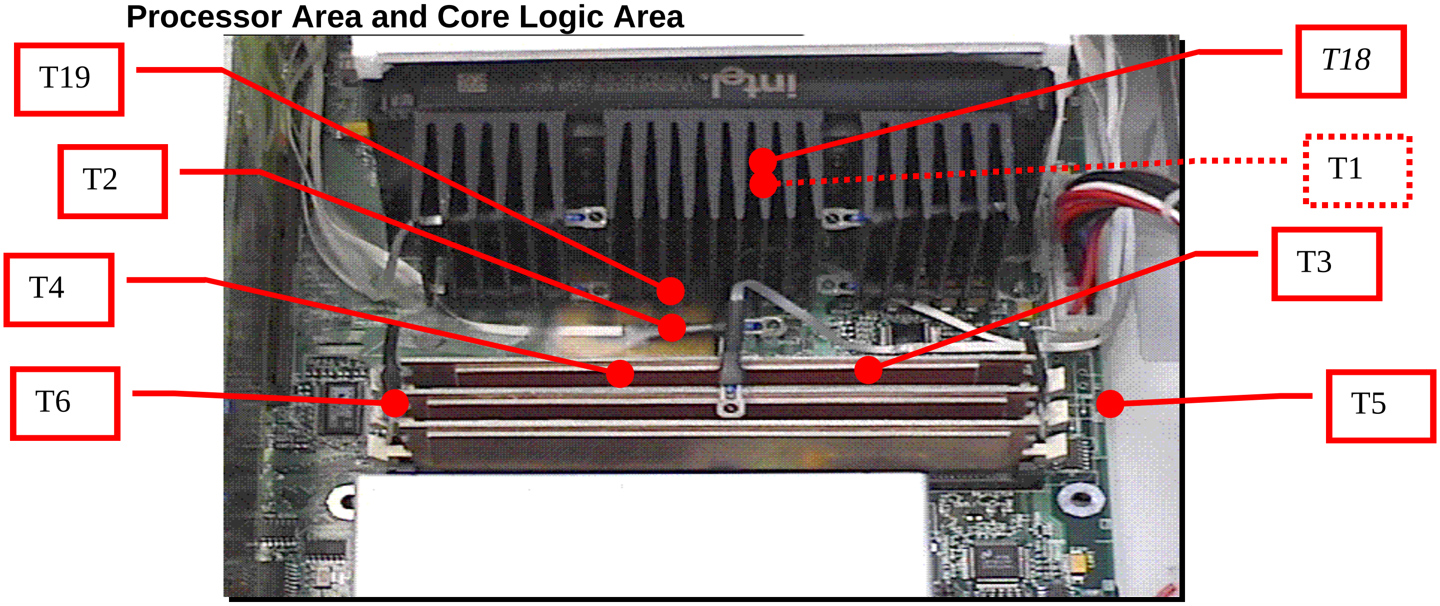
AGP Add-In Card Area



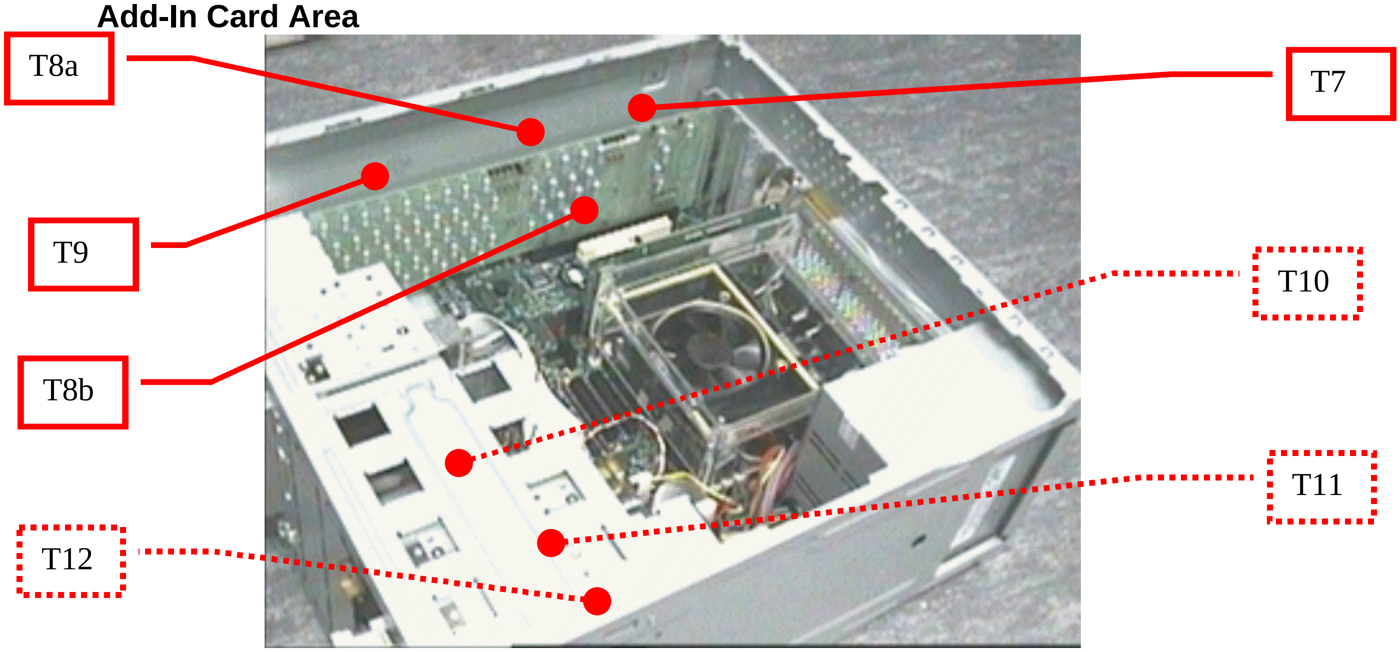
Thermocouple Locations

Sensor	Location	No.
Processor	Processor plate temperature, center of thermal plate	T1
Chipset	Chipset case temperature, center of chip	T2
Memory Ambient	0.1”-0.2” above the top of the memory on right side	T3
Memory Ambient	0.1”-0.2” above the top of the memory on left side	T4
Memory Exit	0.1” above the top of the motherboard on right side	T5
Memory Exit	0.1” above the top of the motherboard on left side	T6
Add-In Card Ambient	0.75” to 1” above add-in cards towards back of chassis	T7
Add-In Card Ambient	0.75” to 1” above add-in cards towards middle of chassis	T8a
Add-In Card Internal Ambient	½ way from bottom of motherboard in-between cards	T8b
Add-In Card Ambient	0.75” to 1” above add-in cards towards front of chassis	T9
Hard Drive Case	On top of active hard drive case	T10
CD ROM	On top of lower CD ROM case	T11
CD ROM	On top of upper CD ROM case	T12
Power Supply Exhaust	0.5” to 1” in front of power supply vent on chassis outside	T13
FDR Vent	0.5” to 1” in front of FDR vent	T14
Internal Power Supply	0.25 to 0.5” in front of internal power supply vent	T15
AGP Case	On top of AGP processor case	T16
AGP Board	On back of AGP card in center of processor	T17
Processor Local	0.25” above center of heat sink	T18
Chipset Local	0.25” above center of chipset	T19
External Ambient	External and away from chassis	T20

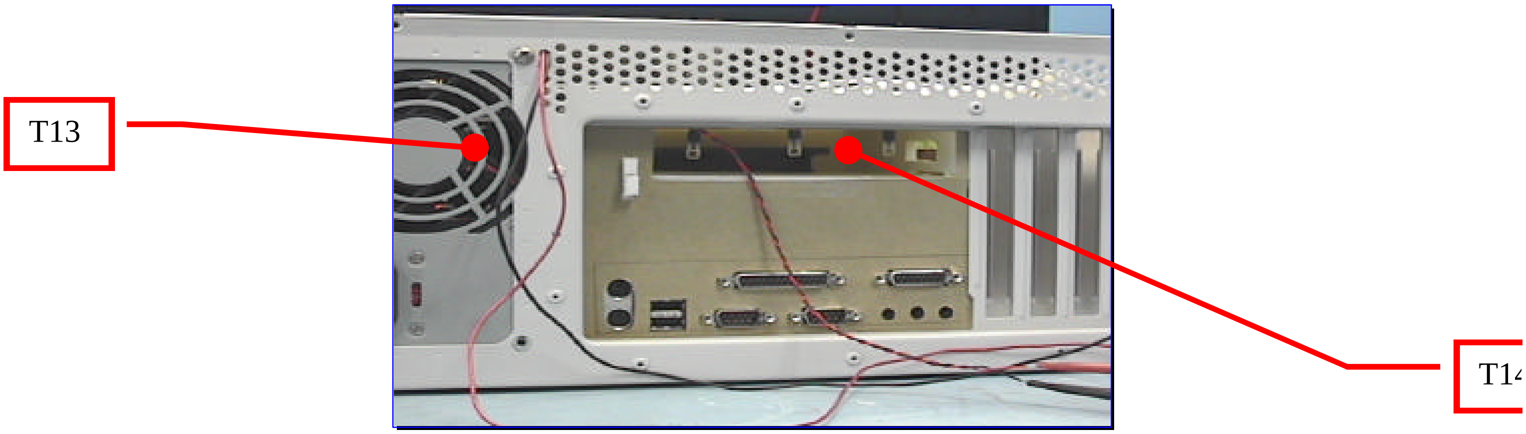
Processor Area and Core Logic Area



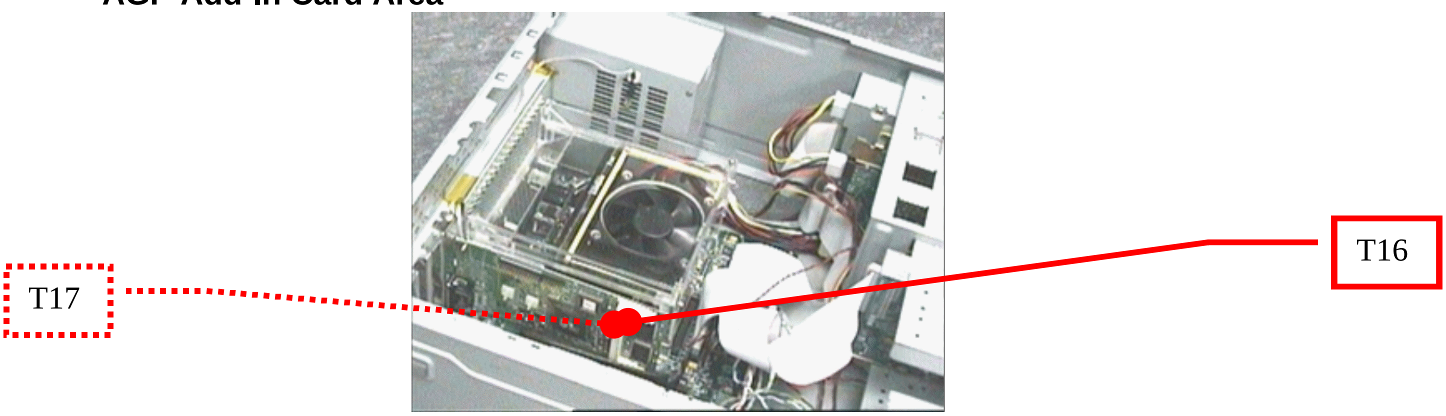
Add-In Card Area



Back I/O Panel Area

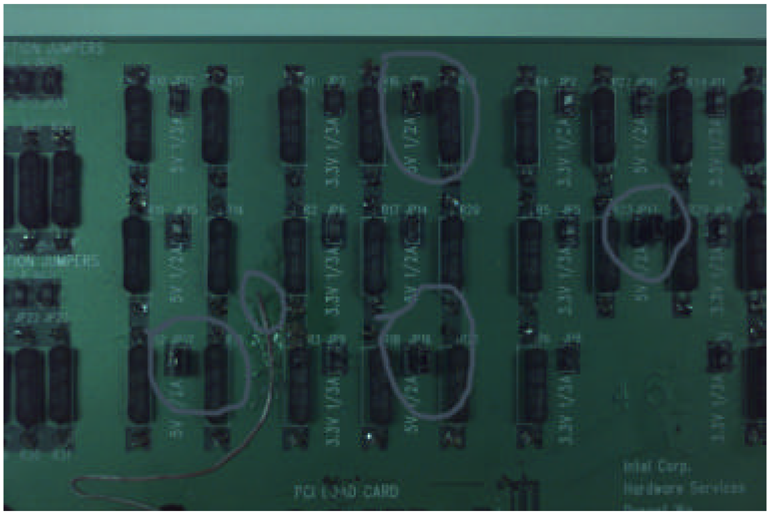


AGP Add-In Card Area

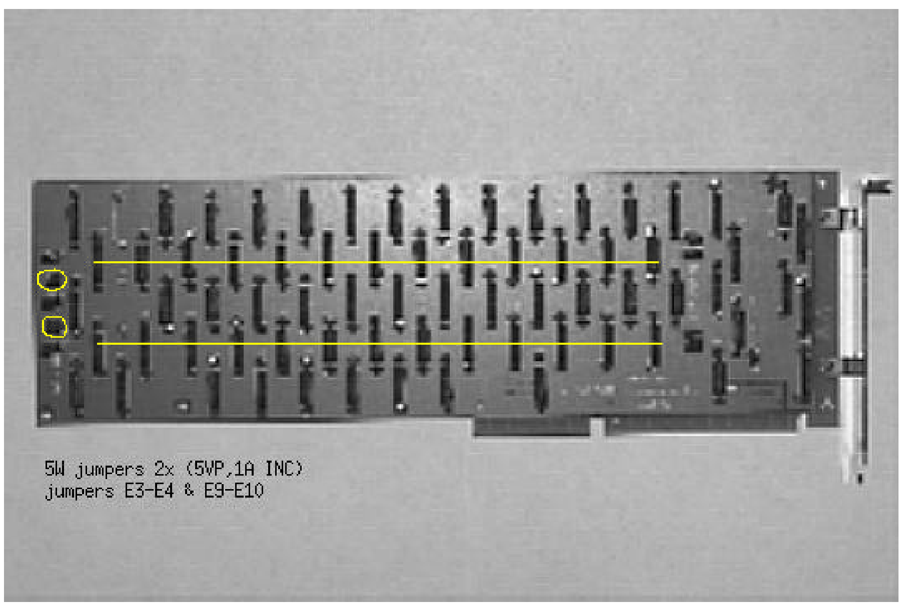


Load Card Configuration

PCI Load Card (10 watt distributed load)



ISA Load Card (10 watt distributed load)



Appendix B: Structural Validation Report

Executive Summary

- **The Low Profile Fan Duct reference design passed shock and vibration tests**
- **The Fan Duct requires support on both the front and back of the duct**

Empirical Validation

The Low Profile Fan Duct was empirically tested to ensure the design met the necessary shock and vibration reliability requirements. The following sections describe the test parameters and results for the Low Profile Fan Duct reference design.

Failure Criteria:

The Fan Duct failure criteria were:

- No visual damage to the duct or other system component
- The system must electrically function before and after each test
- The Fan Duct must not hit the processor core components: processor, chipset, memory, or graphics card.

Test Results

Shock

The Low Profile Fan Duct reference design passed the structural failure criteria in all six drop directions of the shock test. The test consisted of six drops: positive and negative directions of each of the axis as shown in **Figure 25**.

Tests that were run with no rear support bracket showed that the Fan Duct hit the processor heat sink. Although the system still functioned, the long-term reliability of the processor may have been negatively impacted.

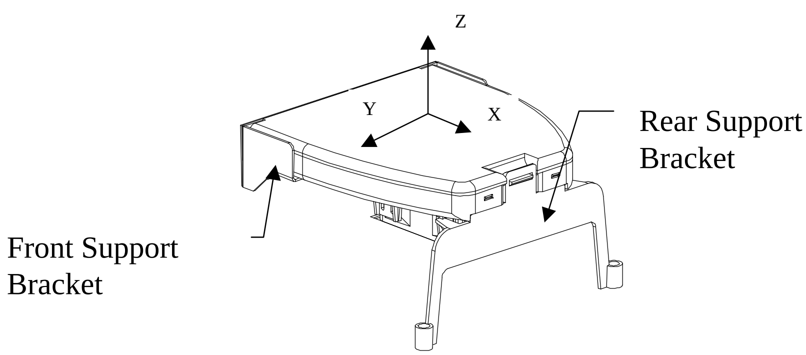


Figure 25. Three Primary Test Axis

Vibration

The Low Profile Fan Duct reference design also passed the structural failure criteria in all 3 directions of the random vibration test. The vibration tests use same 3 axis used in the shock test.

Components Used

Low Profile Fan Duct
The Low Profile Fan Duct with a metal front bracket and a plastic rear bracket was used to perform the validation tests as shown in **Figure 25**. The body of the Fan Duct was made from a urethane mold in order to provide quick prototypes. Due to the weaker properties of urethane over ABS plastics, the urethane duct was considered to be a worst case structural sample.

Motherboard
The motherboard was a Pentium ®II processor with an LX chipset. There were no add-in cards used since the cards would help stiffen the back panel of the chassis.

Chassis
The Low Profile Fan Duct was tested in a production version mini-tower ATX chassis named the Galileo chassis. The Galileo chassis consists of a power supply mounted directly over the Fan Duct with a clearance of approximately 0.07”-0.10”.

Test Settings

Shock Test

The shock test consists of rigidly mounting the assembled chassis on to a shock table. The standard system level shock settings are:

- Pulse Type: Trapezoidal
- Acceleration: 30 Gs
- Duration: 10 ms

Random Vibration Test

The vibration test consists of rigidly mounting the assembled chassis to a vibration table. The standard system level random profile vibration settings are:

- Random Profile: 5 Hz @ .001 g^2/Hz to 20 Hz @ 0.01 g^2/ Hz (slope up) as shown in figure 2
- 20 Hz to 500 Hz @ 0.01 g^2/ Hz (flat)
- Input acceleration is 2.20 g RMS
- 10 minutes per axis in all 3 axes on all samples

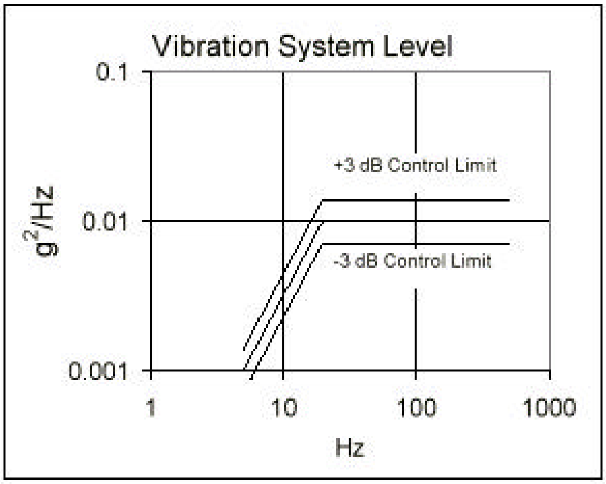


Figure 2. Random Vibration Input Ramp.

Conclusion

The validation tests indicated the current Low Profile Fan Duct provides a robust structural design to ensure a reliable product. The critical parameters for the success of the Fan Duct design consists of providing support from both the back panel and a motherboard support bracket. Any deviations from this support structure must be properly tested.

Appendix C: EMI Test Results

Criteria:
Low Profile Fan Duct should not compromise the EMI performance of an existing ATX chassis.

Test Configuration:

System board:	Seattle ATX mother board
Chassis:	Galileo Minitower ATX*
Processor Speed:	400, 450, and 500 MHz
Fan Duct:	Plastic top section and metal base

Tested both in open chassis and closed chassis configuration in GTEM up to 2 GHz. Test looked for variations to base configuration with Fan Duct compared to configuration without Fan Duct.

* Vent pattern for test: 60% open perforated vent pattern with .170 inch (4.3 mm) diameter holes added to back panel of chassis

Basic Equation for Hole Diameter (max):

λ = 300/f(MHz)

λ = wave length, meters
f = frequency, Hz
D = λ/20 at 5 GHz = 3 mm, (ideal hole diameter)
D = λ/10 at 5 GHz = 6 mm, (max hole diameter)
Note: maximum recommended hole diameter is 4.3 mm

Results and Learnings:

- Metal Fan Duct construction can result in a 5 to 10 dB increase in EMI at Core frequencies of 350 to 400 MHz processors.
- Fan cables to the motherboard can contribute 5 dB at 500 MHz.

Recommendations

- Make the Fan Duct from non-conductive material. EMI Performance is not impacted using a plastic Fan Duct.
- Connect the power cable directly to the power supply, not the motherboard.

Appendix D: Low Profile Heat Sink Drawings

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REVISIONS							
REV	DESCRIPTION	DFT	DATE	CHK	DATE	APVD	DATE
06	OPEN CLIP NOTCH TOLERANCE	R.T.	10/22/97				

NOTES:

1. ALL DIMENSIONS AND TOLERANCES PER ANSI Y14.5M.
4. MATERIAL: 6063-T5 ALUMINUM ALLOY OR MATERIAL WITH EQUIVALENT THERMAL AND MECHANICAL PROPERTIES.
5. FINISH: BLACK ANODIZE, TYPE II.
6. BULK PACKAGE IN QUANTITY USING A SUITABLE SHIPPING CONTAINER AND MARK ITEM IDENTIFICATION NUMBER, QUANTITY AND VENDOR IDENTIFICATION ON OUTSIDE OF SHIPPING CONTAINER PER INTEL MARKING STANDARD 164497.
7. REMOVE ALL BURRS OR SHARP EDGES.

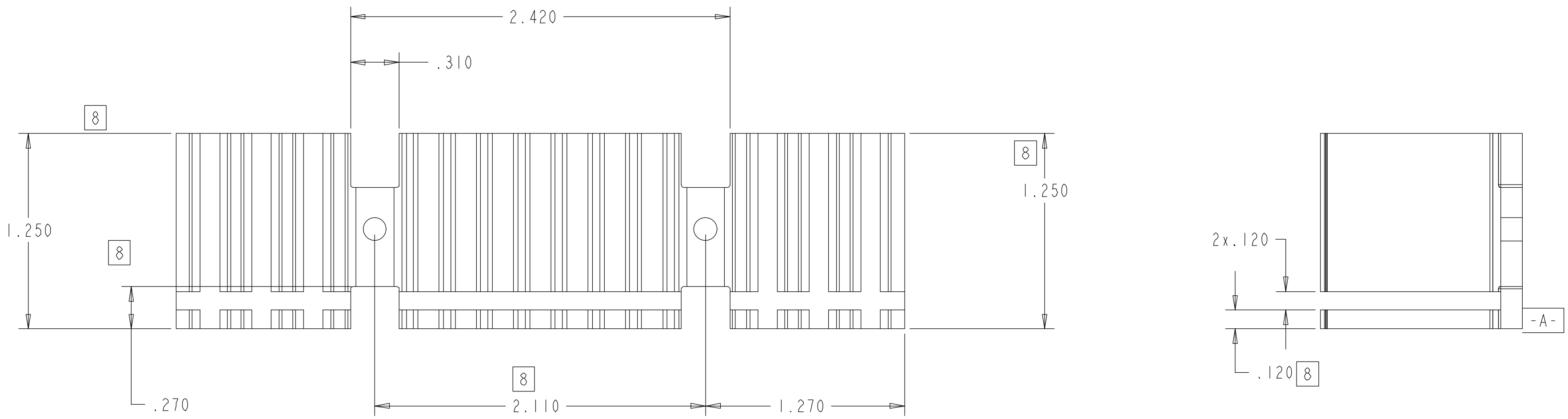
[8] CRITICAL TO FUNCTION DIMENSION.

9. CROSS CUTS ARE FLUSH TO -0.015".

[10] VENDOR ID LOCATION.

[11] MARK PART NUMBER AND DATE CODE IN CONTRASTING COLOR, IN THIS AREA.

[13] EXTRUDER MARKER ALLOWABLE BETWEEN FINS OF TWO SIDE SECTIONS.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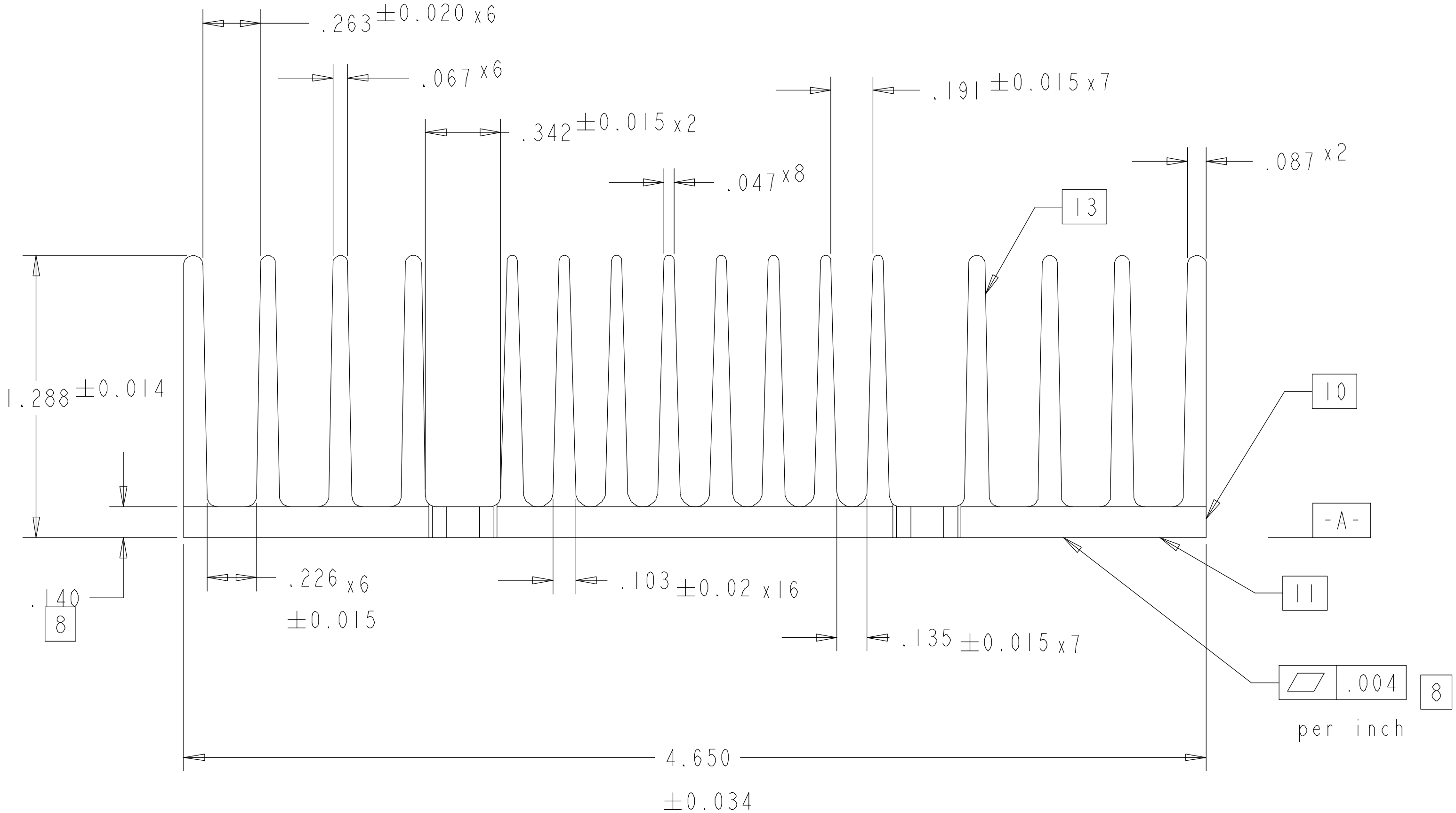
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.067 x6
.342 ±0.015 x2
.047 x8
.191 ±0.015 x7
.087 x2
13
10
1.288 ±0.014
-A-
.140
8
.226 x6
±0.015
.103 ±0.02 x16
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11
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per inch
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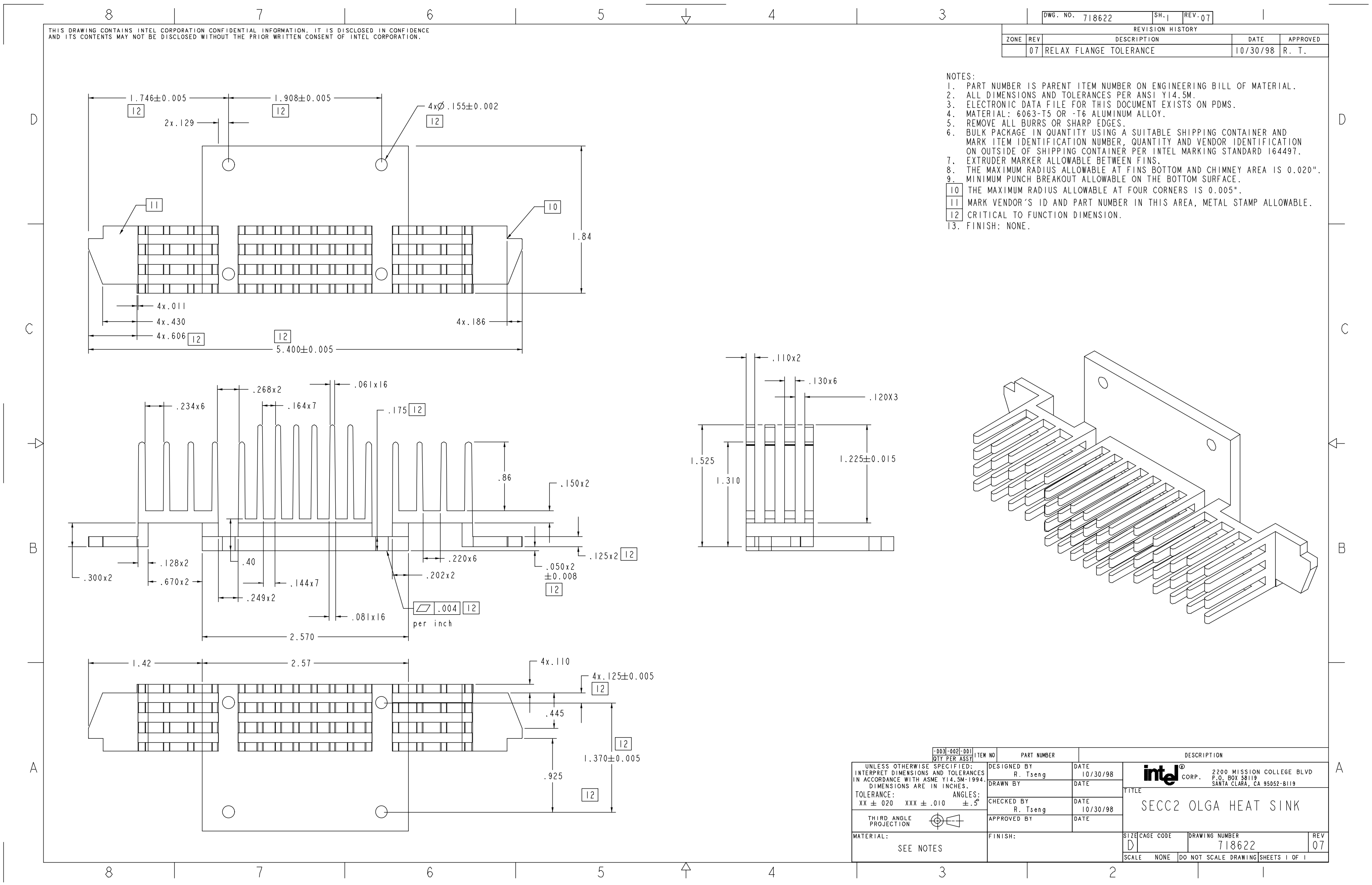

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DWG. NO. 718622 SH. 1 REV. 07
REVISION HISTORY
ZONE REV DESCRIPTION DATE APPROVED
07 RELAX FLANGE TOLERANCE 10/30/98 R. T.
NOTES:
1. PART NUMBER IS PARENT ITEM NUMBER ON ENGINEERING BILL OF MATERIAL.
2. ALL DIMENSIONS AND TOLERANCES PER ANSI Y14.5M.
3. ELECTRONIC DATA FILE FOR THIS DOCUMENT EXISTS ON PDMS.
4. MATERIAL: 6063-T5 OR -T6 ALUMINUM ALLOY.
5. REMOVE ALL BURRS OR SHARP EDGES.
6. BULK PACKAGE IN QUANTITY USING A SUITABLE SHIPPING CONTAINER AND MARK ITEM IDENTIFICATION NUMBER, QUANTITY AND VENDOR IDENTIFICATION ON OUTSIDE OF SHIPPING CONTAINER PER INTEL MARKING STANDARD 164497.
7. EXTRUDER MARKER ALLOWABLE BETWEEN FINS.
8. THE MAXIMUM RADIUS ALLOWABLE AT FINS BOTTOM AND CHIMNEY AREA IS 0.020".
9. MINIMUM PUNCH BREAKOUT ALLOWABLE ON THE BOTTOM SURFACE.
10 THE MAXIMUM RADIUS ALLOWABLE AT FOUR CORNERS IS 0.005".
11 MARK VENDOR'S ID AND PART NUMBER IN THIS AREA, METAL STAMP ALLOWABLE.
12 CRITICAL TO FUNCTION DIMENSION.
13. FINISH: NONE.
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1.908±0.005
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1.84
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5.400±0.005
.234x6
.268x2
.164x7
.061x16
.175
.86
.150x2
.128x2
.300x2
.670x2
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.144x7
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per inch
2.570
.110x2
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-003 -002 -001
QTY PER ASSY
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PART NUMBER
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UNLESS OTHERWISE SPECIFIED:
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DIMENSIONS ARE IN INCHES.
TOLERANCE: XX ± 020 XXX ± .010 ANGLES: ±.5°
THIRD ANGLE PROJECTION
DESIGNED BY R. Tseng DATE 10/30/98
DRAWN BY DATE
CHECKED BY R. Tseng DATE 10/30/98
APPROVED BY DATE
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TITLE
SECC2 OLGA HEAT SINK
MATERIAL: SEE NOTES
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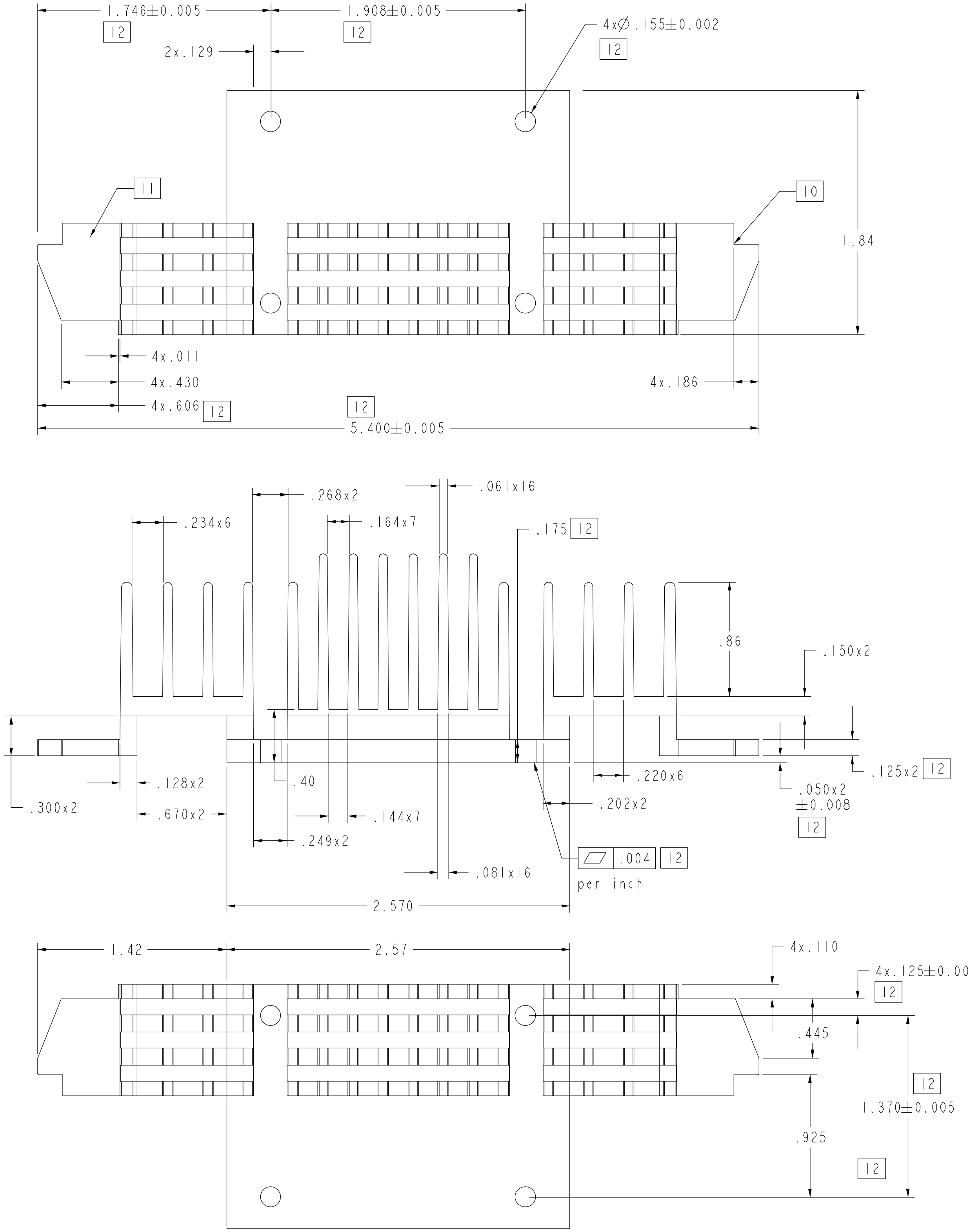

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per inch
.081x16
2.570
1.42
2.57
4x.110
4x.125±0.005
12
.445
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1.370±0.005
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12. CRITICAL TO FUNCTION DIMENSION.
13. FINISH: NONE.